



# Comparison of adjustment speeds in target research and development and capital investment: What did the financial crisis of 2007 change?



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## ABSTRACT

This paper investigates the dynamics of R&D and capital investment using a large sample of US firms during the period 2002–2016. A partial adjustment approach is employed with a specific focus on the impact of the financial crisis on target adjustment speed. Evidence suggests that firms have a target in both types of investment and adjust to it at varying speeds. Specifically, firms adjusted to the capital investment target faster than to R&D investment. However, firms increased the adjustment speed in R&D investment significantly during the crisis, and it has remained at similar levels during the post-crisis period. The changes in adjustment speeds can be explained by several firm-specific characteristics that are related to the ability of firms to raise internal finance.

## 1. Introduction

This paper investigates the dynamic investment behavior of firms with positive research and development (R&D) expenditures. The main objective of the study is to investigate how investment dynamics differ between R&D and fixed capital investment with a focus on the speed of target adjustment. This is done using a large sample of US firms during the period 2002–2016. The sample period enables analysis of the investment decisions before, during and after the global financial crisis of 2007.

The static view of investment stemming from the traditional neo-classical theory of investment assumes that firms operate around their optimal levels, and hence, the observed investment for an average firm at any time is not far from its desired level (see, e.g., Jorgenson, 1963). This implies that when targets change and/or firms move away from their optimal investment (e.g., due to external shocks), they adjust back to their optimal one instantaneously. It is assumed that the costs of target adjustment are negligible. However, the dynamic view acknowledges that capital market imperfections are significant enough to have an impact on the adjustment process (Bloom, Bond, & Van Reenen, 2007; Mueller, 2003). It is argued that while firms desire to revert to their target investment, the desired adjustment is not completed instantly. There are delays in adjusting fully, rendering the adjustment only partial in the first instance.

In a dynamic setting, the speed of adjustment is determined by a trade-off between two types of costs, namely, the costs of reverting back

to the optimal investment (adjustment costs) and the costs of being away from the optimal investment (off-target costs). Although the underlying process is similar, this study argues that the nature of this trade-off, as well as the determinants of optimal levels, change between R&D and capital investments. The ability of firms to raise finance, the cost of financing, and whether investment projects are reversible and firms can afford delaying investment expenditures are among the factors that influence the dynamics.

It is well documented in the literature that firms pursue a target investment policy and that investment targets are variant over time and across firms (Dasgupta, Noe, & Wang, 2011; Gatchev, Pulvino, & Tarhan, 2010). However, while previous research yields valuable insights into the dynamics of fixed capital investment, relatively little is known about the R&D adjustment process. More importantly, there is no prior work that specifically investigates how the speed of adjustment differs between R&D and capital investments and what determines the ability and incentives of firms to adjust to target investment levels. This paper advocates the view that the differences in adjustment speeds do not always stem from the varying adjustment costs between the two types of investment. It is argued that off-target costs are also likely to be heterogeneous across R&D and capital investments and can to some extent explain the observed differences in the adjustment dynamics of both investment targets.

Additionally, this paper investigates how the global financial crisis of 2007 affected the speeds of adjustment in target R&D and capital investment. The financial crisis imposed common exogenous shocks

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that adversely affected the profitability and cash flows of firms as well as their ability to raise external finance. The availability of external funds during and after the crisis was also limited, in particular for new investment projects (Bliss, Cheng, & Denis, 2015; Campello, Graham, & Harvey, 2010; Duchin, Ozbas, & Sensoy, 2010). This study provides a detailed account of how the investment adjustment behavior of firms changed during and after the recent financial crisis in comparison to the pre-crisis period. This is done in relation to both R&D and capital investments. Additionally, the study investigates the firm-specific characteristics that determine the differences in the speeds of adjustment in target levels.

The empirical analysis is conducted using a dataset that comprises 1266 non-financial US firms during the period 2002–2016. The analysis is conducted in two stages. In the first stage, a target model and the speeds of adjustment for each type are estimated for the entire period. The estimations are then repeated separately for the pre-crisis, crisis and post-crisis periods. In the second stage, further tests are conducted to shed light on the firm-specific characteristics that are likely to explain the different adjustment speeds across R&D and capital investments. This is done by classifying firms into sub-groups using firm-specific attributes that capture the extent of financial flexibility and their ability to raise external funding. In the paper, a partial adjustment model is estimated using the generalized method of moments (GMM) estimation procedure. This estimation method helps control effectively for firm heterogeneity and potential endogeneity, while recognizing that capital market conditions may impede a firm's ability to achieve its target investment levels.

The empirical findings provide strong evidence that firms exhibit a long-term target behavior regarding both R&D and capital investment expenditures. In addition, the dynamics of investment behavior are supported—firms attempt to revert back to their optimal levels, albeit at different speeds with respect to each investment type and time period considered. It is found that the average firm in the sample adjusted to its target R&D more slowly than capital investment. Furthermore, the difference became more significant during the crisis period despite that the adjustment was faster for both types. In the aftermath of the crisis period, firms reverted to their pre-crisis adjustment speed regarding capital investment while they maintained quicker adjustment towards target R&D. Further analysis shows that the ability of firms to adjust can be explained by firms' dividend, cash holdings, leverage and stock issue/purchase decisions. The findings suggest that greater financial flexibility provides firms with higher ability to adjust, in particular to the R&D target.

This paper contributes to the literature in two important ways. First, it contributes to the strand of the literature that emphasizes the differences between R&D and capital investments (Brown & Petersen, 2015; Hall, 1992; Peters & Taylor, 2017). There is consensus in the literature that the dynamics of R&D and capital investment are different. Moreover, the target adjustment costs for R&D are greater (Brown, Fazzari, & Petersen, 2009; Li, Liu, & Xue, 2014 and Peters & Taylor, 2017). However, the analysis of this paper expands the literature by providing a comparative empirical analysis with respect to the determinants of and dynamics of R&D and capital investments. Second, the study tests explicitly the impact of the financial crisis of 2007 on the speed of adjustment of both R&D and capital investments. In doing so, the firm-characteristics that can potentially explain the differences in observed speeds of adjustment are also considered. This analysis provides additional valuable insights into the interaction between firm-specific and firm-invariant external factors.

The remainder of the paper is organized as follows. Section 2 develops the hypotheses of investment adjustment speed. Section 3 derives empirical specifications from theory and describes methodology. Section 4 illustrates preliminary data analysis. Section 5 discusses the estimation results, and Section 6 offers the conclusions.

## 2. Main predictions

This study argues that the speed at which firms adjust to their desired levels of investment depends on the type of investment as well as a number of firm characteristics and exogenous shocks. In this respect, two important features of the adjustment process are considered. First, it is acknowledged that firms desire to invest optimally to maximize value and hence take up all the value-increasing investment opportunities. It is hence costly to be away from optimal investment levels (i.e., off-target costs). However, it is important to note that a firm can be off-target not only by undershooting (underinvestment) but also by overshooting its investment target (overinvestment). Both sub-optimality are assumed to be costly to firms and reduce firm value. Second, target adjustment often involves costs that are mainly determined by firm-specific as well as market-wide imperfections (i.e., adjustment costs). The relevant capital imperfections that affect the extent of adjustment costs include informational and agency problems as well as external adverse market conditions that constrain firms and make the cost of external finance greater.

The discussion above implies that being away from optimal levels for long periods are likely to have a negative impact on firm value, and hence, despite the expected significant costs of adjustment, firms would attempt to revert back to their optimal as quickly as possible. That is, the speed of adjustment is clearly determined by the firm's ability and incentives to revert to their optimal levels of investment. While the ability is related to adjustment costs, the incentives are mainly driven by off-target costs. Significant adjustment costs reduce firms' ability to adjust investment levels and hence slow the adjustment process. However, greater off-target costs, *ceteris paribus*, give greater incentives to change investment expenditures and are therefore expected to increase the speed of adjustment. In what follows, it is also assumed that both off-target costs and adjustment costs are significantly greater for R&D investment than capital investment.

### 2.1. Adjustment costs hypothesis

There are distinct characteristics of R&D investment, which can lead to significant off-target and adjustment costs. For example, R&D expenditures are mostly intangible and have lower collateral value and fetch lower values when liquidated (Hall, 1992). Furthermore, it is difficult to value R&D projects as there are usually no organized markets for them (Aboudy & Lev, 2000). Even in the presence of an observed market price, it is argued that the market price cannot fully reflect all information, mainly due to asymmetric information between insiders and outsiders (Griliches, 1995). The literature argues that standard solutions provided to adverse selection problems, such as signaling, reputation acquisition and financial intermediation, are likely to fail to work for innovation intensive firms (see, e.g., Takalo & Tanayama, 2010).

Another distinct characteristic of R&D expenditures is that it comprises mainly wages, and hiring, firing and training costs of highly skilled employees. R&D costs are generally sunk, and innovation markets are segmented with oligopolistic characteristics, whereas tacit knowledge and skills of scientists make it difficult to fire them (Bloom & Van Reenen, 2002; Trushin, 2011). For the adjustment to target, installing new investment takes time and requires sunk costs, delivery lags, and learning (Cooper & Haltiwanger, 2006). Finally, R&D firms are more constrained in raising further finance, and borrowing constraints impose additional costs in adjusting investment upward. Carpenter and Petersen (2002) show that financing constraints and funding gaps arising from imperfections in capital markets affect high-tech sectors more than others. The above discussion leads to the following hypothesis.

**H1.** The speed of adjustment to attain the optimal level of R&D investment is lower than that for capital investment.

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